STRESS ANALYSIS OF HOMOGENEOUS DOMAINS USING IMPLICIT MESHING

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The computational techniques available for solving the elasto-static field problem may be broadly classified into two categories: (1) methods which *explicitly* discretize the domain, and (2) methods which *implicitly* discretize the domain. The class of *explicit* methods contains the standard finite-element method as well as the more recent meshless methods. It is well known that both of these methods can be used for stress analysis in elasto-statics. Included in the class of *implicit* methods is the embedded-domain method (or fictitious-domain method). In the embedded-domain method the given domain (inclusion domain) is embedded into a geometrically simple domain. The embedding domain is then discretized, taking full advantage of the simple geometry. The inclusion domain inherits the discretization of the embedding domain as well as the solution obtained on it.

Currently in industry the method of choice for stress analysis is the standard finite-element method. It has become evident in recent years that a major impediment to rapid stress analysis of three-dimensional geometrically complex domains using finite-element analysis is the initial time spent creating an appropriate finite-element mesh. Even with the advent of sophisticated automatic mesh generators, significant human resources are required to create a finite-element mesh for a geometrically complex domain that is appropriate for the analysis of *stress*. The current meshless methods hold the promise of significantly reducing the discretization effort, but are still constrained by the need to explicitly place points judiciously around complex geometrical features. The use of the finite-element method *in conjunction* with the embedded-domain concept offers an attractive alternative.

The use of the Galerkin finite-element method to discretize the embedding domain will be referred to as *implicit meshing*. The application of implicit meshing to linear elasto-static *stress* analysis was investigated. As a first step, only two-dimensional homogeneous domains were considered. It was found that accurate approximations to the stress fields of geometrically complex domains can be obtained using implicit meshing *if* (1) finite elements are used that result in a displacement field with C^1 continuity (e.g. the bicubic Hermite element), and (2) the finite-element stiffness matrices are integrated accurately. A novel algorithm was developed for integrating exactly the weak form of the governing equations on a domain bounded by a triangular tessellation. Both the displacement boundary conditions and the nonzero traction boundary conditions must be enforced via Lagrange multipliers. A number of example problems were constructed to illustrate the methods success, and comparisons with the traditional finite-element were obtained.

Future developments will include extension to three-dimensional problems, traditional locally adaptive bisection methods, and extension to composite domains. The methodology may be embedded into commercial finite-element packages as a ‘user element’.